

## Retrospective Study

# Peripheral portal vein-oriented non-dilated bile duct puncture for percutaneous transhepatic biliary drainage

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**Institutional review board statement:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the Chiba University Hospital. Because of the retrospective design, approval of the ethic commission was not always required.

**Informed consent statement:** Informed consent was obtained from all individual participants as to the percutaneous biliary drainage as part of the treatment for biliary disorders.

**Conflict-of-interest statement:** We have no potential conflicts of interest to declare.

**Data sharing statement:** Technical appendix, statistical code, and dataset available from the corresponding author at [h-shimizu@faculty.chiba-u.jp](mailto:h-shimizu@faculty.chiba-u.jp). Consent was not obtained from the study participants because the present data are retrospective, de-identified, and anonymized; therefore, the risk of identification is low.

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## Abstract

**AIM:** To evaluate the efficacy of peripheral portal vein (PV)-oriented non-dilated bile duct (BD) puncture for percutaneous transhepatic biliary drainage (PTBD).

**METHODS:** Thirty-five patients with non-dilated BDs underwent PTBD for the management of various biliary disorders, including benign bilioenteric anastomotic stricture ( $n = 24$ ), BD stricture ( $n = 5$ ) associated with iatrogenic BD injury, and postoperative biliary leakage ( $n = 6$ ). Under ultrasonographic guidance, percutaneous transhepatic puncture using a 21-G needle was performed along the running course of the peripheral targeted non-dilated BD (preferably B6 for right-sided approach, and B3 for left-sided approach) or along the accompanying PV when the BD was not well visualized. This technique could provide an appropriate insertion angle of less than  $30^\circ$  between the puncture needle and BD running course. The puncture needle was then advanced slightly beyond the accompanying PV. The needle tip was moved slightly backward while injecting a small amount of contrast agent to obtain the BD image, followed by insertion of a 0.018-inch guide wire (GW). A drainage catheter was then placed using

a two-step GW method.

**RESULTS:** PTBD was successful in 33 (94.3%) of the 35 patients with non-dilated intrahepatic BDs. A right-sided approach was performed in 25 cases, while a left-sided approach was performed in 10 cases. In 31 patients, the first PTBD attempt proved successful. Four cases required a second attempt a few days later to place a drainage catheter. PTBD was successful in two cases, but the second attempt also failed in the other two cases, probably due to poor breath-holding ability. Although most patients ( $n = 26$ ) had been experiencing cholangitis with fever (including septic condition in 8 cases) before PTBD, only 5 (14.3%) patients encountered PTBD procedure-related complications, such as transient hemobilia and cholangitis. No major complications such as bilioarterial fistula or portal thrombosis were observed. There was no mortality in our series.

**CONCLUSION:** Peripheral PV-oriented BD puncture for PTBD in patients with non-dilated BDs is a safe and effective procedure for BD stricture and postoperative bile leakage.

**Key words:** Percutaneous transhepatic biliary drainage; Cholangitis; Obstructive jaundice; Non-dilated bile duct

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**Core tip:** Percutaneous transhepatic biliary drainage (PTBD) offers a valuable alternative for access to the biliary system when endoscopic biliary drainage is impossible or infeasible. PTBD is generally performed in jaundiced patients with dilated bile ducts (BDs). However, some patients inevitably require PTBD even in the absence of dilated BD. Achieving needle access to the non-dilated BD is a challenging procedure. The present study reported on detailed technical aspects of peripheral portal vein-oriented BD puncture for PTBD in patients with non-dilated BDs, and also examined the safety and success rates of this procedure.

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## INTRODUCTION

At present, endoscopic retrograde biliary drainage (ERBD) is the first-line treatment for patients with obstructive jaundice caused by benign<sup>[1,2]</sup> or malignant bile duct (BD) stricture<sup>[3-5]</sup>. However, the endoscopic

transpapillary approach can often be difficult or even impossible in patients undergoing distal gastrectomy with Billroth II reconstruction or bilioenteric Roux-en Y anastomosis after extrahepatic BD resection<sup>[6,7]</sup> in spite of recent improvement of balloon-enteroscope-assisted ERBD<sup>[8]</sup>. In such cases, percutaneous transhepatic biliary drainage (PTBD) offers a valuable alternative for access to the biliary system. PTBD still plays an important role<sup>[9,10]</sup>, when an endoscopic approach is unsuccessful or infeasible<sup>[11,12]</sup>.

PTBD is generally performed in jaundiced patients with dilated intrahepatic BD<sup>[13,14]</sup>. As a result, BD cannulation is easily achieved in most cases. However, PTBD in patients without intrahepatic BD dilatation is often very difficult<sup>[15-18]</sup> because the drainage catheter has to be inserted into the very small-caliber BD. A recent quality improvement guideline for PTBD reported that the threshold of success rate for non-dilated ducts was 65%<sup>[19]</sup>. However, some cases inevitably require PTBD even in the absence of a dilated intrahepatic BD, such as in cases of recurrent cholangitis resulting from BD stricture or bilioenteric anastomotic stricture, particularly when signs of a septic or pre-septic condition are present. Furthermore, when patients encounter biliary leakage from the resected surface of the liver after hepatectomy or biliary leakage associated with BD injury during laparoscopic cholecystectomy (Lap-C)<sup>[20,21]</sup>, the intrahepatic BD remains non-dilated in most cases<sup>[22,23]</sup>. In such cases, PTBD can be technically demanding, but may offer the most simple and effective treatment for postoperative biliary leakage<sup>[24-26]</sup>.

The present study reported on the detailed technical aspects of peripheral portal vein (PV)-oriented BD puncture for PTBD in patients with non-dilated intrahepatic BDs. We also evaluated the safety and success rates of our PTBD procedure in patients with non-dilated BDs.

## MATERIALS AND METHODS

Between 2001 and 2014, PTBD procedures were performed for 405 patients at our institution, including 35 patients with non-dilated intrahepatic BDs (20 men and 15 women; mean age, 64.5 years; range, 38-75 years). Baseline characteristics of the patients are shown in Table 1. Non-dilated BDs were defined as peripheral BDs measuring < 2 mm in diameter or by visualization of peripheral BDs smaller than the adjacent PV<sup>[27]</sup>, based on ultrasonography (US). Twenty-seven patients had previously undergone operations at other hospitals and were referred to our institution due to recurrent cholangitis or biliary leakage after surgery.

Underlying pathologies were as follows: 24 patients with benign bilioenteric anastomotic stricture after extrahepatic BD resection due to BD injuries during Lap-C ( $n = 14$ ) or open cholecystectomy ( $n = 2$ ), after pancreatoduodenectomy ( $n = 4$ ) or after living

**Table 1** Baseline characteristics of the patients (*n* = 35)

Characteristic	
Gender	
Male/female	20/15
Age (yr)	64.5 (38-75) <sup>1</sup>
T-BiL (mg/dL)	3.8 (1.4-8.2)
ALP (IU/L)	784 (236-2082)
Cholangitis	
Present/absent	9/26
Hepatolithiasis	
Present/absent	10/15
Indication for biliary drainage <i>n</i> (%)	
Bilioenteric anastomotic stricture	24 (68)
Bile duct stricture	5 (15)
Bile leak after initial surgery	6 (18)

<sup>1</sup>mean (range). T-BiL: Total bilirubin; ALP: Alkaline phosphatase.

donor liver transplantation (*n* = 4); 5 patients with benign BD stricture after BD primary repair due to BD injury during Lap-C (*n* = 3) or with primary sclerosing cholangitis (*n* = 2); and 6 patients with bile leakage after hepatectomy (*n* = 3), Lap-C (*n* = 2) or living donor liver transplantation (*n* = 1) (Table 2). US and multidetector-row computed tomography (MDCT) were performed for all patients before PTBD procedures. The position of the targeted peripheral bile duct in relation to the accompanying PV was evaluated by MDCT. The total of 35 cases included 7 cases in which endoscopic approaches had failed, including 4 cases with double-balloon enteroscopy due to Roux-en-Y reconstruction. In the remaining 28 cases, the endoscopic approach had not been attempted because of the postoperative reconstructed anatomy.

#### **Peripheral PV-oriented BD puncture technique with two-step guide-wire method**

PTBD procedures were performed under local anesthesia with mild sedation. The most appropriate BD for targeted puncture was the B6 peripheral branch for the right-sided approach (Figures 1 and 2) or B3 for the left-sided approach, because the distance between the skin and puncture site of the BD was short and running course of the target BD was mostly straight from the hepatic hilus to the peripheral puncture site.

Under ultrasonographic guidance, the non-dilated peripheral branch of B6 or B3 was punctured with a 21-G needle (PTCD Two Step Drainage Set; Cook, Tokyo, Japan) along the running course of the BD or accompanying PV in the case when the targeted BD was not well visualized (Figure 1A), and the puncture needle was advanced slightly beyond the accompanying PV. After removal of the inner stylet, the needle tip was moved slightly backward while injecting a very small amount of contrast agent (0.5-1.0 mL) to obtain a BD image (Figure 1B), because the back flow of bile could not be obtained in most cases with the non-dilated BD. Once a BD image was obtained, contrast agent was quickly injected to acquire a

**Table 2** Outcomes of percutaneous transhepatic biliary drainage in patients with nondilated intrahepatic duct *n* (%)

Technical success	33 (94.3)
First PTBD	31
Second PTBD <sup>1</sup>	2
PTBD procedure-related complication	5 (14.3)
Transient hemobilia	1
Cholangitis	4

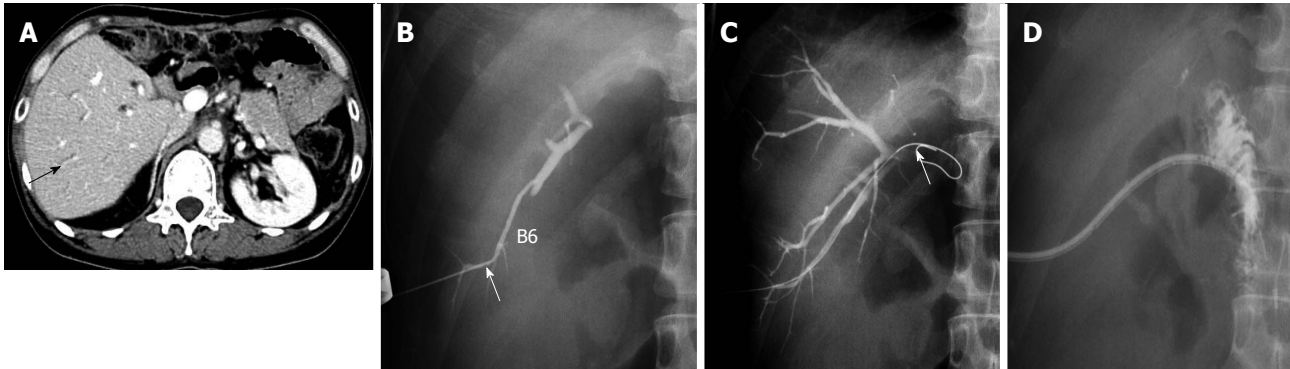
<sup>1</sup>Second PTBD attempt was performed a few days later in all cases. PTBD: Percutaneous transhepatic biliary drainage.

clear image of the hilar BD. A 0.018-inch guide-wire (GW) was then advanced carefully into the BD while controlling the needle tip (Figure 1C). During this process, the insertion angle between the puncture needle and running course of the BD (Figure 3) is very important. The angle should be less than 30°, otherwise, insertion of the assembly set catheter (PTCD Two Step Drainage Set; Cook) into the BD over the thin, 0.018-inch GW may become quite difficult.

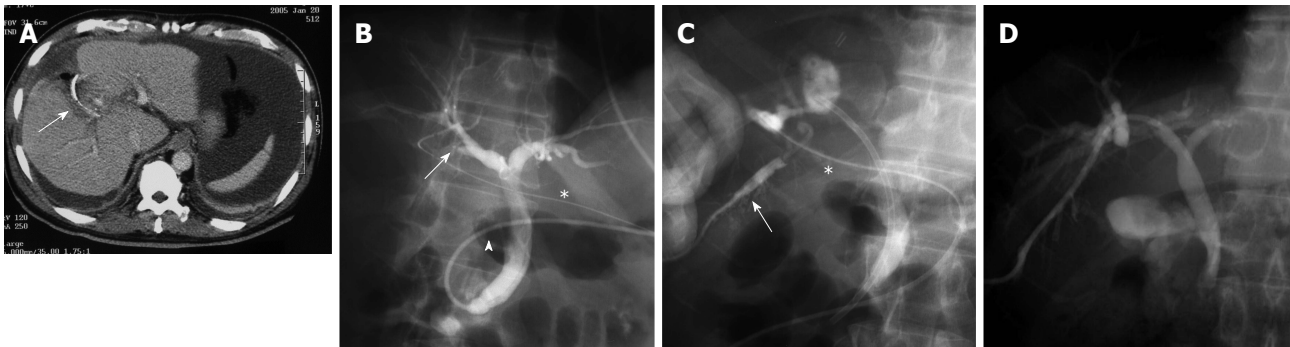
After the thin GW was inserted and locked at a secure position in the BD, the 21-G puncture needle was removed. The assembly set (PTCD Two Step Drainage Set; Cook), consisting of a metallic cannula and inner sheath and outer sheath catheters, was slowly inserted over the thin GW, and advanced into the targeted BD. The metallic cannula and inner sheath catheter were then removed, leaving the outer sheath catheter behind in the BD. Cholangiography was performed to confirm that this catheter had been correctly placed into the BD. A 0.035-inch hydrophilic GW (Radifocus, Terumo, Tokyo, Japan) was then inserted to a secure position in the biliary system. A 7-Fr catheter with a distal curve (Seeking catheter; Hanako Medical, Saitama, Japan) was then inserted along the GW (Figure 1D) and the BD stricture or anastomotic stricture was crossed using the GW. A final 8-Fr drainage tube (Straight; Hanako Medical) with side holes was advanced to the appropriate position for internal-external drainage (Figure 1D). After an interval of several days, dilation of the stricture site was performed with a balloon catheter and plastic dilator (Cook). The drainage catheter was exchanged in size up to 14-18 Fr, and kept for 3-6 mo after the first PTBD placement to avoid re-stricture. However, in this study, PTBD procedures were considered as successful when the PTBD catheter was successfully inserted into the BD.

## **RESULTS**

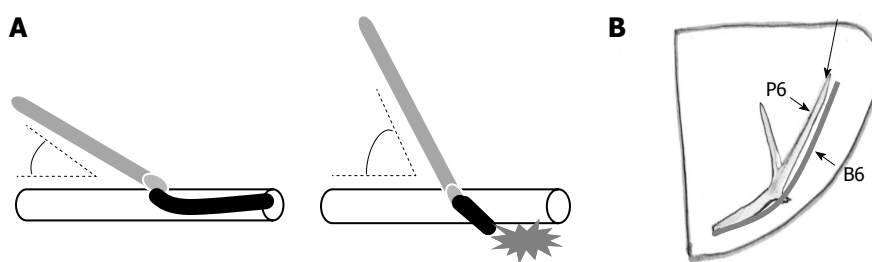
PTBD was successful in 33 (94.3%) of the 35 patients with non-dilated intrahepatic BDs. In 31 patients, the first PTBD attempt proved successful. Four cases required a second attempt a few days later to place the drainage catheter. This second attempt was successful for two cases, but failed in the other two cases,



**Figure 1** A 57-year-old man who had undergone living donor liver transplantation with right posterior sectional graft 8 mo earlier presented with recurrent cholangitis due to stricture of the bilioenteric anastomosis. A: Computed tomography shows that the intrahepatic bile duct (BD) is not dilated. The arrow indicates a peripheral branch of B6; B: Under ultrasonographic guidance, a non-dilated peripheral branch of B6 is punctured along its running course with a 21-G needle; C: While controlling the needle tip, a 0.018-inch guide-wire (GW) is inserted carefully into the BD; D: When the hydrophilic 0.035-inch GW crosses the anastomotic stricture, a 7-Fr catheter with distal curve crosses the stenotic bilioenteric anastomosis and advances into the jejunal loop.



**Figure 2** A 65-year-old man who had undergone segment 5 resection and radiofrequency ablation in segment 1 for hepatocellular carcinoma presented with bile leakage after surgery. A: Computed tomography shows non-dilated intrahepatic bile ducts and an intraperitoneal drainage tube (arrow) placed at the time of surgery; B: Cholangiogram via the endoscopic nasobiliary drainage tube (arrowhead) reveals stricture of the posterior sectional bile duct (arrow). Asterisk shows the intraperitoneal drain placed at the time of surgery; C: Non-dilated peripheral B6 (arrow) is punctured with a 21-G needle. Asterisk shows the intraperitoneal drain placed at the time of surgery; D: An 8-Fr biliary drainage tube is advanced through the strictured right posterior sectional bile duct and placed from B6 to the common bile duct.



**Figure 3** This technique increased the possibility of the puncture needle crossing the targeted non-dilated bile duct, and also provided an appropriate angle to insert the drainage catheter for the next step. A: The insertion angle between the puncture needle and running course of the bile duct (BD) should be less than 30°; B: Under ultrasonographic guidance, percutaneous transhepatic puncture is performed along the running course of the targeted peripheral non-dilated BD (B6 for right-sided approach) or along the accompanying portal vein (P6) when the BD is not well visualized. This technique can provide an appropriate insertion angle of less than 30° between the puncture needle and BD running course.

probably due to poor breath-holding ability (Table 2). A right-sided approach *via* B6 was performed in 23 cases, and *via* B5 in 2 cases, while a left-sided approach was performed through B3 in 9 cases, and B2 in 1 case.

Although most patients ( $n = 26$ ) had been suffering

from cholangitis with fever including septic condition in 8 cases before PTBD, only 5 (14.3%) of 35 patients encountered PTBD procedure-related complications, such as transient hemobilia and cholangitis (Table 2). No major complications such as bilioarterial fistula or portal thrombosis were observed. There was no



mortality in our series.

## DISCUSSION

Successful biliary drainage is essential for the management of recurrent cholangitis due to BD stricture or bilioenteric anastomotic stricture<sup>[1,2]</sup>, and also for effective treatment of postoperative biliary leakage<sup>[24-26]</sup>. Although ERBD is currently the first-line treatment, endoscopic transpapillary access to the biliary system can often prove difficult, because of postoperative anatomical conditions such as with Billroth II reconstruction or bilioenteric Roux-en-Y anastomosis<sup>[6,7]</sup>. In such cases, PTBD offers a valuable alternative for accessing the biliary system<sup>[11,12]</sup>. Surgical management may also be one of the options for the treatment of BD or bilioenteric anastomotic stricture. However, surgical re-exploration and repair of the biliary system, such as BD reconstruction or bilioenteric re-anastomosis, can be extremely difficult and complex in patients with long-lasting cholangitis<sup>[28-30]</sup>, particularly due to Bismuth type III or IV<sup>[31]</sup> biliary stricture<sup>[32,33]</sup>.

Non-dilated intrahepatic BDs have generally been defined as peripheral BDs measuring < 2 mm in diameter or by visualization of a BD smaller than the adjacent PV<sup>[27]</sup> based on US. According to previous reports, the success rate for PTBD in patients with non-dilated BDs has ranged from 75% to 90%<sup>[17,18,24-26]</sup>, and complication rates were also higher as compared to patients with dilated BDs<sup>[16]</sup>. According to the recent quality improvement guideline for PTBD<sup>[19]</sup>, the threshold of success rate for non-dilated ducts is 65%, and the rates of major complications, such as hemorrhage and sepsis, are 5%. In our series, PTBD was technically successful in 94.3% of patients without any major complications. In cases with non-dilated BDs, BD puncture is generally performed much closer to the hepatic hilum, because the target BD is simply larger. However, BD puncture close to the hepatic hilum may carry a high risk of vascular complications, including bilioarterial fistula and PV thrombosis. Peripheral BD puncture is therefore preferable to central BD puncture, but is technically demanding, resulting in lower success rates. Funaki *et al.*<sup>[27]</sup> clearly reported that many BD punctures and passes were required for BD cannulation in patients with non-dilated BDs.

With recent improvements of the resolution of US, peripheral BD can be visualized in most cases. However, after a failure of the first BD puncture, the target non-dilated BD was not well visualized in most cases. In such situations, we punctured along the peripheral PV running parallel with a target BD using a 21-G needle. This technique increased the possibility of the puncture needle crossing the targeted non-dilated BD, and also provided an appropriate angle to insert the drainage catheter for the next step (Figure 3). A similar puncture technique was reported by Lee *et al.*<sup>[15]</sup>, who termed the procedure the "parallel technique". Our series successfully performed the PTBD

procedure using a 21-G puncture needle with a two-step GW method exchanging from a 0.018-inch GW to a 0.035-inch GW. Furthermore, no major complications such as bilioarterial fistula or PV thrombosis after PTBD procedure were encountered in this series. Minor PTBD-related complications included transient hemobilia and cholangitis, with a morbidity rate of 14.2%. Accordingly, the most advantageous point of this technique is the safe procedure, as the puncture site is very peripheral and major complications such as portal thrombosis or bilioarterial fistula are unlikely to occur. On the other hand, this procedure may be technically demanding. Therefore, it is better for a biliary physician, surgeon or radiologist who is familiar with the biliary anatomy and has mastered ordinary PTBD techniques to perform this procedure.

In conclusion, peripheral PV-oriented BD puncture with two-step GW method for PTBD is safe and feasible, offering high success rates in patients with non-dilated intrahepatic BDs. This procedure is useful and effective for the management of BD or bilioenteric anastomosis strictures and postoperative biliary leakage.

## COMMENTS

### Background

At present, endoscopic retrograde biliary drainage is the first-line treatment for patients with obstructive jaundice caused by benign or malignant bile duct (BD) stricture. However, the endoscopic transpapillary approach can often prove difficult or even impossible in patients undergoing distal gastrectomy with Billroth II reconstruction or bilioenteric Roux-en-Y anastomosis after extrahepatic BD resection. Percutaneous transhepatic biliary drainage (PTBD) offers a valuable alternative for access to the biliary system when endoscopic biliary drainage is impossible or infeasible. PTBD is generally performed in jaundiced patients with dilated BDs. However, some cases inevitably require PTBD even in the absence of a dilated BD. Achieving needle access to the non-dilated BD is challenging. The present study reported on the detailed technical aspects of peripheral portal vein (PV)-oriented BD puncture for PTBD in patients with non-dilated BDs, and the safety and success rates of this procedure.

### Research frontiers

According to previous reports, the success rate for PTBD in patients with non-dilated BDs has ranged from 75% to 90%, and complication rates were also higher as compared to patients with dilated BDs. According to the recent quality improvement guideline for PTBD, the threshold of success rate for non-dilated ducts is 65%, and the rates of major complications, such as hemorrhage and sepsis, are 5%.

### Innovations and breakthroughs

In cases with non-dilated BDs, BD puncture is generally performed much closer to the hepatic hilum because the target BD is simply larger. However, BD puncture close to the hepatic hilum may carry a high risk of vascular complications. Peripheral BD puncture is therefore preferable to central BD puncture, but is technically demanding, resulting in lower success rates. Under ultrasonographic guidance, percutaneous transhepatic puncture using a 21-G needle was performed along the running course of the peripheral targeted non-dilated BD (preferably B6 for a right-sided approach, and B3 for a left-sided approach) or along the accompanying PV when the BD was not well visualized. This strategy increased the probability of non-dilated BD puncture without risk and could also provide an appropriate insertion angle of less than 30° between the puncture needle and BD running course. In these series, PTBD was technically successful in 94.3% of patients without any major complications.

## Applications

Peripheral PV-oriented BD puncture with two-step guide wire method for PTBD is safe and feasible, offering high success rates in patients with non-dilated intrahepatic BD. This procedure is useful and effective for the management of BD or bilioenteric anastomosis strictures and postoperative biliary leakage.

## Terminology

Non-dilated bile ducts (BDs): peripheral BDs measuring < 2 mm in diameter or by visualization of peripheral BDs smaller than the adjacent PV based on ultrasonography.

## Peer-review

The authors of this paper evaluated the efficacy of peripheral PV-oriented non-dilated BD puncture for PTBD. In their series, PTBD was technically successful in 94.3% of patients without any major complications. Peripheral PV-oriented non-dilated BD puncture for PTBD is therefore a safe and effective procedure for BD stricture and postoperative bile leakage, with a high success rate.

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